

Annual Report

1957

LAKE STATES FOREST EXPERIMENT STATION
FOREST SERVICE · U.S. DEPARTMENT OF AGRICULTURE

The Lake States Forest Experiment Station is one of nine regional forest research stations administered by the Forest Service, U. S. Department of Agriculture. It is maintained in cooperation with the University of Minnesota. Through Federal legislation, it is authorized to carry on forest research for the benefit of all forestry agencies in the region, including public forestry groups, wood-using industries, and other forest owners.

The territory in which the Station operates includes the Lake States (Michigan, Wisconsin, and Minnesota) and the Northern Great Plains. Besides the Station headquarters in St. Paul, field offices are located at East Lansing and Marquette, Mich.; Rhinelander and Wausau, Wis.; Grand Rapids, Minn.; and Bottineau, N. Dak.

March 19, 1958

Rocky Mt. Forest &
Range Exp. Station
% Agronomy Dept., Univ. Wyoming
Laramie, Wyoming

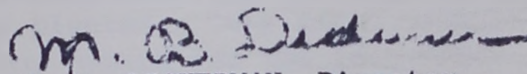
OW

Dear Sir:

Regulations of the Department of Agriculture require that our mailing list be revised and corrected annually. It will be necessary to drop your name from our mailing list unless we are advised of your continued interest. Returning this letter within 30 days will assure receipt of Station publications for the next year.

Your name and address appear on our records as shown by the above addressograph impression. Please do not obliterate the impression but make any necessary corrections below.

Very truly yours,



M. B. DICKERMAN, Director
Lake States Forest Experiment Station
St. Paul Campus, University of Minn.
St. Paul 1, Minn.

☐ Above address is correct

☐ Above address is incorrect. It should be

R-LS
REPORTS
Station's Annual, 1957

March 19, 1958

Dear Sir:

This is our Annual Report for 1957.

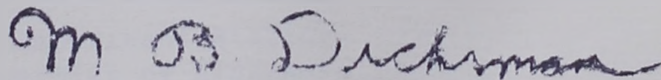
The first section covers the most significant events of the past year in our research program and in the organization of the Station. The second, and by far the greater part, has been devoted to a review of past, present, and planned research in the field of reforestation.

Planting efforts in the Lake States have been increasing steadily in recent years. In 1956 about 100,000 acres were planted, two-thirds of this acreage being privately owned. This is encouraging. But an estimated 14 percent of the commercial forest land is still nonproductive and will remain so for a long time unless it is planted. This fact, considered in conjunction with the strong demand for the long-fiber softwood in the region as well as the wood needs of our growing population, shows the importance of our planting program.

Research of the Lake States Station has helped to guide the planting that has been accomplished up to the present, and, along with studies now under way, will continue to do so. Many of these studies are described in the report.

If you have any comments or suggestions on the work of the Station described in the report, we shall be glad to have them.

Very truly yours,

A handwritten signature in dark ink, appearing to read "M B Dickerman". The signature is fluid and cursive, with the first letters of the first and last names being capitalized and prominent.

M. B. DICKERMAN, Director

Enc.

ANNUAL REPORT

of the

LAKE STATES FOREST EXPERIMENT STATION

for the year 1957

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A N N U A L R E P O R T of the
LAKE STATES FOREST EXPERIMENT STATION

1957

INTRODUCTION

This report for 1957 is in two parts. First are the highlights of the year--those events that were milestones in our technical progress or had a significant bearing on our organization and program responsibilities. Second is a review of past, present, and planned research as it relates to the planting of forest trees in the Lake States.

We've chosen planting as the theme of the report for several reasons. Behind all of them is the fact that the forest lands of this region can and should produce a larger share of the wood and other benefits that will be needed in the years ahead than they are producing at present. More land must be put to work if the long-fiber softwood used in the region is to be grown here. The continuing rapid growth in population will have an increasing impact on demands for wood. As the shift nationally is made from old-growth to second-growth timber, the favorable geographical location of the Lake States with respect to markets and population centers becomes increasingly important.

In the face of this anticipated need, an estimated 14 percent of the commercial forest land in the Lake States is now producing little or nothing of tangible value. Furthermore, where repeat surveys have been made, the acreage of nonstocked forest land shows an increase. This is "plantable" land in Forest Survey terminology. Most of it will remain nonproductive for a long time unless it is planted.

The current rate of planting is about 100,000 acres per year. Recent increases are encouraging. Now is a good time to review research progress in reforestation, consider some of the studies now under way, and examine briefly some of the needs that have become evident.

The increase in both scope and number of research programs in recent years has had an impact in various ways. A number of new projects were begun this year, many of them in cooperation with other agencies. Dissemination of research findings and demonstration activities have increased. New problems are arising in fields previously outside the scope of the Station's program. A few of these new developments are mentioned briefly below.

Survey of potential research areas made in Driftless Area.--The unglaciated section of southwest Wisconsin and southeast Minnesota, commonly called "The Driftless Area," represents one of the most serious forest soil and water problem areas in the Lake States. As a first step toward undertaking a research program aimed at solving the more pressing problems, a survey was made for the Wisconsin Conservation Department to select a tract suitable for an experimental forest devoted to watershed and forest management research. To get some background data and form a basis for future studies, a short-term project was undertaken in the same area during the past summer. Data were collected on soil moisture behavior under different land use conditions and on the distribution and depth of tree roots on some natural and planted sites.

Basic watershed management studies begun in Lower Michigan.--As a result of the interest, financial support, and cooperation of the Michigan Department of Conservation, watershed studies were started this year with the employment of one full-time technician. Although Michigan is generally considered rich in its water resource, sufficient danger signs are appearing to recommend the undertaking of basic studies aimed at staying abreast of these increasing problems--before they become even more serious and damaging to the economy. These studies will be aimed at solving some of the fundamental relationships between forest cover and water consumption, type and depth of frost penetration, snow accumulation and melt, and ground water recharge. To help guide the research program, an analysis of the water resources and water problems on the State's forests and wildlands has been made.

New forest survey to start in Missouri.--In 1958, Forest Survey crews will move to Missouri to begin the second survey of that State. Preparing the work plan for this job has been a major effort of the Forest Survey group during 1957. In this effort we have worked closely with the Missouri National Forests and the Central States Forest Experiment Station, especially with the Research Center at Columbia, Mo. Our aim has been to build a survey design that can be applied throughout the Central States region and that will provide the permanent plots necessary for re-measurement in future surveys. To get the best design possible we have drawn on experience at other Forest Experiment Stations and the National Forests, and have conducted extensive research in Forest Survey techniques on projects in Minnesota and Michigan. Pilot scale studies have

Single-ring infiltrometers used for studying infiltration rate of trampled compacted pasture land in the Driftless Area of southwestern Wisconsin.



been made in southern Wisconsin. From all these sources a new survey design has emerged, incorporating many items of information that were lacking in the first Central States survey.

Studies of forest taxation and ownership initiated.--We have planned two new studies on factors affecting the practice of forestry on private lands. In cooperation with the Wisconsin Conservation Department, the Station will gather data on taxation of forest lands in northern Wisconsin and compare the relative tax burden of the general property tax with that of the Forest Crop Law tax. The objective here is to get an indication of the relative effect on net income of the two tax systems. This study will show for typical properties how much of the expected income over a period of years is taken by the general property tax and how much would have been taken by the Forest Crop Law. Results of this study should help foresters and tax experts to judge the adequacy of the Forest Crop Law as it now stands. In another study in central Wisconsin the Station will gather data on the attitudes of small private owners toward forestry as a business and toward forestry assistance programs. We will try to discover which characteristics influence owners to manage or not to manage forest lands. In addition, the study will provide estimates on present forest land use by owner groups.

Improved design of charcoal kilns reduces cycle time and increases yields.--Of the several studies being conducted in utilization of low-grade hardwoods, special mention should be made of research progress in charcoal production in small kilns. Three kiln interior structural materials--insulated sheet metal, cinder concrete blocks, and castable refractory--are being tested in three experimental 3-cord units to determine operational, maintenance, and economic factors applying to each. Improved design features such as multiple stacks and center firing, with and without an external source of heat and mechanically controlled air supply, have substantially reduced cycle time and increased yields of good-quality charcoal. Studies of the costs of small-kiln operation are also being continued in a 7-cord unit incorporating improved design features of double-wall construction and multiple stacks.

Substantial progress made on a system of evaluating timber quality in northern hardwoods.--The need for a more effective means of evaluating quality in standing timber was brought into sharp focus this year at a

Servicewide conference on timber quality at Madison, Wis. Recommendations were made at this meeting to develop more precise grades for standing timber and forest products. Present needs are for research-based methods of evaluating quality which eventually will lead to more accurate grading of timber and products in the harvest of raw material and in industry operations. The Station's program of research in this field made substantial progress through improvement in use of colored photo-slides for study of defects and through streamlining of data processing.

Cooperative study on sugar maple decay completed.--Publication of a Station Paper, "Deterioration of Sugar Maple Following Logging Damage," by Dr. Gene A. Hesterberg culminated a cooperative study with the University of Michigan and the Michigan College of Mining and Technology on one phase of a serious disease problem. Heart rots cause more growth loss and timber quality reduction than all other diseases combined.

New tree disease problems noted.--In 1957 an unusual number of new diseases of unknown causes appeared. A maple blight in some Wisconsin stands is causing mortality of alarming proportions in hard maple. Heavy mortality in black spruce nursery stock occurred in several nurseries. A new canker disease of jack pine was found in northern Minnesota. In addition to these new problems, the jack pine - sweetfern rust was found to be causing considerably more damage than was previously supposed.



Analysis of data on logging scars in sugar maple showed that more than two-thirds of the stem scars occurred in the butt 16-foot log. Logging scars frequently result in heart rot. Results of this study were published in Station Paper No. 51, "Deterioration of Sugar Maple Following Logging Damage."

Cooperative studies begun for silvicultural control of spruce budworm.--
The Minnesota and Ontario Paper Company and the Superior National Forest are cooperating with the Station in locating and establishing plots for the study of stand susceptibility to spruce budworm damage under various stand conditions. An important part of the plan will be a pilot-plant type of operation in which an uncut check area will be compared with several types of cutting. This and other studies of the spruce budworm rank high in importance, for budworm populations in northern Minnesota increased this year as predicted. Heavy defoliation occurred in the spruce-fir type along the Canadian border. A severe infestation threatens public and private lands on about 15,000 acres on the Kabetogama Peninsula east of International Falls.

Forest Insect Field Laboratory completed.--The investigations on the spruce budworm require many collections and rearings of larvae and pupae. To facilitate these studies a new forest insect field laboratory was constructed this year on the Kawishiwi Experimental Forest near Ely, Minn. An interesting feature in the design is the numerous windows at front and back, materially reducing eye strain during close examination of study material. A separate building allows ample space for rearing work and storage.

Third Lake States Forest Tree Improvement Conference held.--Eighty foresters and others interested in developing better forest trees attended the Third Lake States Forest Tree Improvement Conference at the University of Minnesota's North Central School of Agriculture in Grand Rapids, Minn., on Sept. 17 and 18. The program included papers on the application of forest tree

The new Forest Insect Field Laboratory at Ely, Minn. Interior view shows spruce budworm studies under way. Women are counting egg masses; men are estimating current defoliation.



improvement practices in the Lake States and on recent advances in forest tree improvement. A field trip was made to seed-source plantations and red pine management studies of the Station, red pine selections of the University of Wisconsin, nursery facilities of the Blandin Paper Company, and genetics outplantings of the University of Minnesota. Station staff member Paul O. Rudolf, as Executive Secretary of the Lake States Forest Tree Improvement Committee, was largely responsible for planning and conducting the conference.

Northern Institute of Forest Genetics opened.--The Northern Institute of Forest Genetics, a field laboratory of the Station, was formally opened at Rhinelander, Wis., on June 6. Nearly 150 people, including many leaders in Lake States forestry, inspected the greenhouse, laboratory, and offices and the exhibits on genetics, physiology, and pathology prepared by the staff. Tree improvement research for northern species will be concentrated at the Institute. The objective is to improve the quality of timber produced in the northern forests. Dr. Hans Nienstaedt is in charge of the Institute.



Over 2,000 visitors inspect demonstration areas and field tests.--Each year many people visit our field experiments and demonstration areas to learn the trends in and results of forest research. Many of these visitors are conservation-minded people such as science teachers and students from colleges and high schools, 4-H clubs, and Scout troops. The greater number, however, are forest owners or



The new Northern Institute of Forest Genetics at Rhinelander, Wis. Exterior view shows office and laboratory; greenhouse is at the back of the building. Interior view from left to right: Dr. Hans Nienstaedt, geneticist, examines preserved bud specimens; Dr. Philip Larson, physiologist, examines specimens showing summerwood development; Gilbert Mattson, forestry aide, weighs pollen.

managers, representatives from industry, game specialists, and research men interested in obtaining information of practical value in their own work. This year visitors at our field units numbered over 2,000.

New Economics Chief appointed.--James T. Morgan was appointed Chief of the Economics Division this year. Mr. Morgan has had wide experience in forest survey work, both at the Lake States and Central States Stations. He succeeded R. N. Cunningham, who retired on May 31 after 40 years in the U. S. Forest Service, 27 of them at the Lake States Station. Mr. Cunningham was largely responsible for developing and improving the timber resource surveys in the Lake States.

Changes in staff.--A number of changes occurred in the technical staff this year. Entered on duty were John R. Cooley, Thomas P. Ginnaty, Robert G. Knutson, Robert N. Stone, and Carl H. Tubbs for Forest Survey; Herman J. Heikkenen, Richard E. Lohrey, and William D. Striffler at the East Lansing, Mich., field unit; Robert L. Cross at Marquette, Mich.; and Donald Schmiede at St. Paul. Mr. Schmiede will head up Forest Insect Survey activities. Paul C. Guilkey of the East Lansing center was transferred to the Southeastern Experiment Station, and Allan Hartong of Forest Survey went to the Northeastern Station. Other members of the staff who accepted positions in industry or at the universities were entomologists Roger Grenier, L. C. Beckwith, and Arnold T. Drooz; pathologist J. R. Parmeter, and research forester William Boughner.

Many staff members do postgraduate work.--The Station urges staff members to work toward advanced degrees. This year 20 members of the Station staff were doing some postgraduate study; the majority of them are well along toward obtaining Ph. D. degrees.

Over 100 reports published.--Some of the results of the Station's work were published in over 100 reports in 1957. These included one book (Forest Nursery Practice in the Lake States), 13 Station Papers, 54 articles for various professional and semiprofessional periodicals, and 43 Technical Notes. Among the Station Papers published were reports on the silvical characteristics of 6 of the Lake States tree species. Reports on 9 additional species are being prepared.

PLANTING RESEARCH IN THE LAKE STATES

The Planting History

The history of planting in the three Lake States begins in the last years of the nineteenth century when plantations were established by a few public agencies and private individuals, partly in reaction to concern over the future of our forest resources. By 1911 the States and the Federal Government had begun reforestation activities. The total area planted amounted to about 150,000 acres by 1926. Planting operations of the Civilian Conservation Corps helped to bring this total to about 1 $\frac{1}{4}$ million acres by 1939. After World War II each year showed an increase in annual plantings: 55,000 acres in 1950, 69,000 in 1952, 81,000 in 1954, and in 1956 nearly 100,000 acres. Altogether, over 2 million acres have been planted to trees in the Lake States.

The bulk of long-established plantings are on public lands. But the larger part of the acreage planted in recent years is privately owned. In 1950, 43 percent of the total, or 24,000 acres, was on private land. By 1956 this proportion had increased to two-thirds of the total, or 66,000 acres.

Research of the Lake States Station has helped to guide the planting that has been accomplished up to the present. Results of studies of seed collection, nursery practice, site preparation, planting techniques, and cultural operations have been published. A selected list of these reports begins on page 31.

Outlook for the Future

In 1952, when Timber Resource Review estimates were made, over 7 $\frac{1}{2}$ million acres in the Lake States were classed as plantable area--nonstocked or poorly stocked land on which planting is desirable and practical and where satisfactory tree regeneration will not occur naturally within a reasonable length of time. Not included are the millions of acres of forest land that at present offer poor planting chances or have understocked stands in need of reinforcement planting.

In 1952 the plantable area of commercial forest land, when broken down by States and ownership classes, was as shown in the table at the top of the next page.

The present rate of planting, about 100,000 acres a year, seems certain to increase. In addition to the greater industrial interest shown, the Conservation Reserve phase of the Soil Bank program and other agricultural programs are having their effect. To meet the demand for trees, new nurseries are being established and old nurseries reactivated or expanded.

Ownership or trusteeship	Total	Michigan	Minnesota	Wisconsin
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In Thousand Acres

Federal				
National Forest	404	245	96	63
Other Federal	33	1	15	17
Total	437	246	111	80
State	513	250	200	63
County and municipal	797	50	400	347
Private	5,904	2,324	1,550	2,030
Total commercial	7,651	2,870	2,261	2,520

Despite the favorable outlook for future expansion of planting, we still have a long way to go. Seven and one-half million acres of nonproducing land is a large area in relation to the present annual planting rate. Furthermore, the present rate is having no significant effect on reducing the plantable area. One may well question whether we can long afford to delay a much greater expansion of our reforestation activities.

Areas in need of reforestation vary greatly in plantability. The former pine site below presents no problem in preparing the ground and planting the trees; this site needs to be reforested to stabilize the soil as well as to produce needed softwoods. Contrast this kind of site with the alder brush thicket shown on the next page.





This alder brush thicket presents a more difficult planting site than that shown on the preceding page; the thicket would have to be destroyed by use of selective herbicides. Even then the problem of establishing trees in the resulting heavy sod has yet to be solved.

Recognizing the big planting job ahead, the Station has had, and will continue, studies aimed at solution of the major problems. A number of broad fields of activity are involved. These are summarized in the following pages.

Surveys Aid Planning of Research and Action Programs

Basic data on existing conditions are essential to the planning of research and action programs. Within the past few years we have devoted increasing attention to obtaining such information as it relates to the planting problem.

Rate of Natural Regeneration of Plantable Area to be Obtained

To keep information current on plantable area throughout the region, permanent survey plots are being established on nonstocked land as well as other forest land. Periodic remeasurements of these plots will indicate the trend of natural regeneration, a factor that may decrease or increase the need for planting.

Forest Survey Modifications Increase Plantable Area Information

More needs to be known about the nature of the plantable area. Recent Forest Survey designs give some of this information. For instance, in Wisconsin planting needs are being appraised in each county. Areas are classified as to difficulty of planting, chances for tree survival, and the species and method of planting best suited to the site.

Special Survey Made of Established Plantings

Too little is known about the character of plantations that have resulted from past reforestation efforts and the reasons for present problems. To obtain this information on all forest ownerships in the north half of Lower Michigan, a study was begun in 1957 by the Station in cooperation with the Lower Michigan National Forest, the Michigan Department of Conservation, and the Consumers Power Company. Shipping records of planting stock are being sampled and several hundred are being traced to the land. By field examination, estimates can be made of the ratio of successfully planted trees to the number received. Plot measurements within the planted area will show what has happened to the plantings since establishment.

The data from this study will strengthen estimates of the planting job ahead for this area in several ways: They will provide better estimates of the acreage of acceptable plantations, show the need for reinforcement plantings to bring substandard areas up to adequate stocking, check current appraisal surveys of damage from insects and other causes, and point out aspects of planting and plantation management that need further research.

Ownership Studies to Continue

The characteristics of different classes of forest landowners will be studied in 1957-58. This will continue the Station's work on ownership problems, as exemplified by a recent study in Lower Michigan in cooperation with Michigan State University.

Economic Aspects of Planting Need More Emphasis

What factors influence the owner of potential forest land in deciding whether to plant trees, what kind of forest product--pulpwood, poles, veneer logs--he will produce, and how intensive his management will be? The answers to these questions are needed as a guide toward research in the economic aspects of planting.

The Station has established several studies in this field of research. One concerns the information needed by farmers interested in Soil Bank planting, many of whom have had little previous contact with forestry activities. In the summer of 1956 the Station consulted public forestry officials to find out what aspects of Soil Bank planting are most in need of research. Results indicated that costs and returns of plantations under different practices and intensities of management are of most concern to landowners who must decide whether to plant trees, establish pasture, or continue the land in annual crops.

Such information is indeed essential to all owners who contemplate planting trees. Some basic information on alternative practices in establishing, growing, and caring for plantations has already been accumulated, but additional research is needed. When sufficient data are obtained, meaningful economic appraisals will become possible.

Production of Planting Stock

An important aspect of the planting problem is production of thrifty planting stock. This involves not only effective operation of the nurseries producing forest tree stock in the region (about 40 in 1955) but also the acquisition of an adequate quantity and quality of seed.

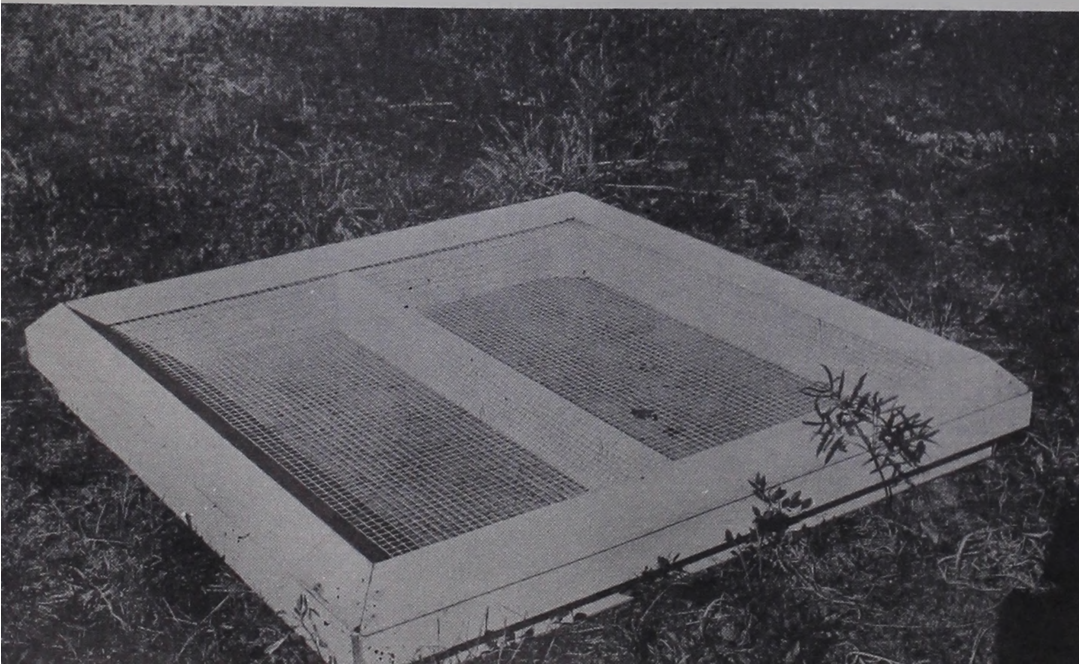
Seed Crop Reports to Continue

To produce planting stock we need seed of the right species, in sufficient quantity, at the right time. There are complications in obtaining this combination. Irregularity of seed production is characteristic of most forest trees.

The Station began preparing annual tree seed crop reports in 1946. Experience over a period of years is needed to guide seed procurement and crop prediction. Observations for some 20 species have been summarized for several localities in the Lake States region.

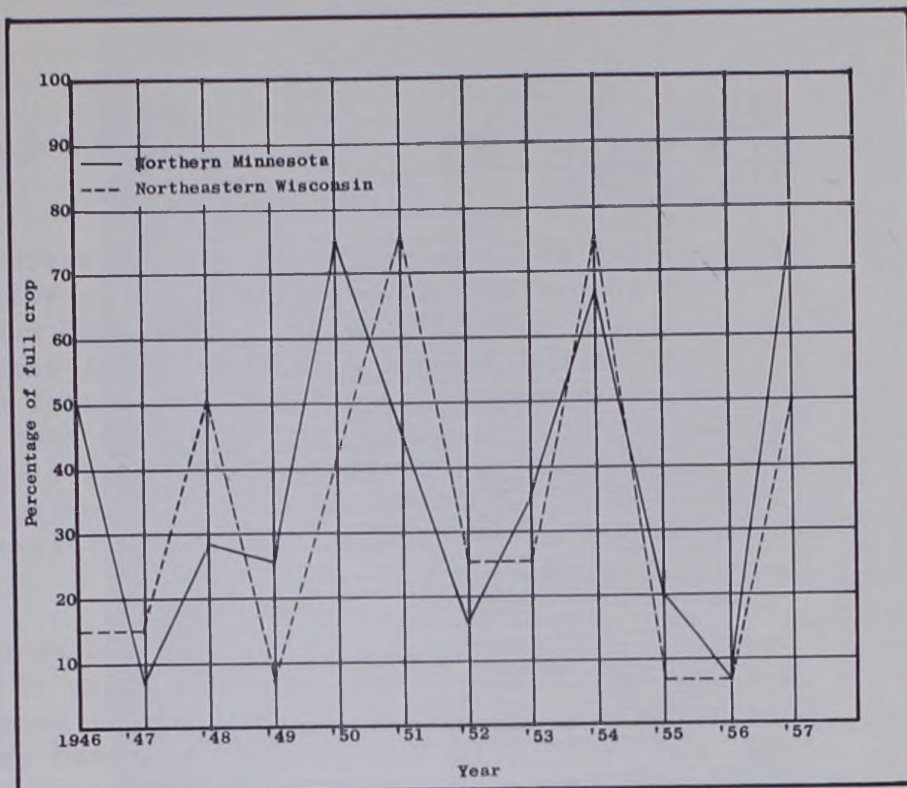
Occasionally, as in 1950, good crops are produced by most forest tree species throughout the region. There are some years, such as 1949, when seed crops are very poor for most species. In most years, however, there is considerable variation among species in a locality, and a species usually varies considerably from one locality to another.

A more detailed look at the record for red pine, the most widely used species in reforestation in the region, may clarify some of these generalities. It indicates (see chart) a rather general agreement in the



Seed traps are used to measure annual seed crops. They are also used to measure the effects of experimental regeneration tests on the amount of seed available under various conditions.

Annual seed crops
of red pine in
two Lake States
localities.



trend of seed crop production in two localities. Generally, peaks and troughs of production are similar, although they may be off a year from one locality to another.

A longer record of performance is needed, so we'll continue these summaries. They also will be useful in guiding research on the causes of variability in seed crops and in studies of ways in which trees can be stimulated to produce seed when it is needed.

Results
of Nursery Studies
Published

Over the years the Station has conducted many experiments on the collection and handling of seed, seedbed preparation and sowing, transplanting, nursery protection, and the efficient and economical operation of a nursery. Observations from these tests and from the experience gained by Lake States nursery superintendents have been assembled in a book, "Forest Nursery Practice in the Lake States" (USDA Handbook No. 110), published in 1957. Authors are J. H. Stoeckeler of this Station and G. W. Jones of the Forest Service, Region 9.

Accumulated research results and experience in growing conifer stock for planting in the Northern Plains is now being summarized.

Control
for Nursery Root Rots
Being Developed

Control studies have been under way for several years on the white pine root rot in the Forest Service nursery at Wellston, Mich. This disease causes losses in seedlings and transplants running as high as 95 percent. Although not 100 percent effective in all cases, either formaldehyde applied at a rate of $1\frac{1}{2}$ ounces per square foot or methyl bromide applied at the rate of 1.6 pounds per 100 square feet will greatly reduce mortality. The methyl bromide treatment has been adopted as standard practice at the nursery. In addition to reducing losses in seedbeds, it reduces transplant bed losses, results in larger, more vigorous stock, and is an effective weed control.

As an aid to providing more effective and economical control, efforts are also being made to determine the cause of the disease in a cooperative study with the Plant Pathology Department at Michigan State University. It is believed the disease is caused by a fungus, a nematode, or a nematode-fungus complex. These leads are being followed up.

Some small-scale control tests are also being conducted on a new problem that developed this season: some nurseries lost about 50 percent of their black spruce transplant stock. The cause of the mortality is unknown, but the symptoms are those of a root rot similar to that on white pine at Wellston, Mich.; they are not, however, believed to be identical. The Forest Service nursery at Eveleth, Minn., is conducting the tests with the Station's assistance; the same practices that have been effective for the white pine root rot are being employed.

Forest Tree Improvement

The major aim of tree planting is to increase productivity of the land. That's accomplished by planting desirable species where they will grow well. Tree improvement is an aid to stepping up production of the trees planted. Stock that is faster growing, more vigorous, and with wood of better quality and greater resistance to insects and diseases will certainly out-produce run-of-the-mill seedlings. There are short-term and long-term aspects to such improvement.

Source of Seed is
Key to Short-Term Tree Improvement

Improved seedling establishment and final yields of wood result when stock is grown from seed well adapted to the planting area. Geographic seed source tests have long been a part of the Station's program. They've been of great value in outlining seed procurement areas for red pine, a job done this past year by the Lake States Forest Tree Improvement Committee. Tests of jack pine and white spruce now under way will aid in determining suitable seed procurement zones for those species.

White and Norway spruce seed source study 16 years after planting; includes seed from 13 European and North American sources.

Red pine seed orchards are being established by several of the administrative agencies to assure vigorous well-formed parent stock as well as proper geographic source. Wisconsin has begun a verified seed program to assure good geographic adaptation. These are definite signs of progress in improving seedling adaptability to the planting site.



Research in Breeding and Vegetative Propagation is Basic to Longer Term Genetic Improvement

The Northern Institute of Forest Genetics at Rhinelander, Wis., is the focal point for the Station's genetics research. Superior trees are being located and their progenies tested to ensure a reliable source of high-quality seed and vegetative material. Propagation through rooting of cuttings is under study. Physiological problems such as flowering, wood formation, and root initiation are being investigated to determine the factors that control these processes. Early emphasis is being placed on white spruce, one of our most important pulping species, but some studies are being made of other valuable Lake States species.

An essential in genetics research is the production of numbers of individual trees with exactly the same genetic makeup as the selected parent. The only way to do this is through vegetative propagation--grafting of the rooting of cuttings.

One of the current studies concerns pretreatment for fall grafting of white spruce. Past research has shown spring grafting to be best for

this species. But fall grafting is desirable because of the heavy press of nursery, planting, and pollination work in the spring. Furthermore, if successful techniques for fall grafting were available, vegetative propagation wood could be collected at the same time seed is collected.

In this study groups of the stock plants before grafting were subjected to ordinary light and temperature, long day (20 hours light per day), short day (13 hours light per day), and a combination of short day and chilling at 41° F. After grafting in September the plants were exposed to short day, long day, and various combinations of daylength and chilling treatments. Results in brief indicated that (1) any pretreatment of the stock plants that keeps them in good growing condition throughout the summer is favorable to graft survival, (2) when postgrafting treatment results in marked changes in the physiology of the stock plant (as moving from long day to short day), low scion survival results, and (3) growth of the scions is affected markedly by postgrafting treatments but little by stock pretreatments; chilling for about 8 weeks is necessary to break dormancy and produce maximum growth. By using a combination of long day and chilling treatments, white spruce scions from mother trees more than 30 years old were fall-grafted in the greenhouse with a take of 60 percent or better.

Another study is directed toward speeding up the growth of selected seedlings, which would be a great boon to breeding research. Potted young white spruce seedlings were exposed to short day, long day, chilling (up to 12 weeks at 36° F.), and combinations of these conditions. Treatment of one series was begun in July and another in September. Results indicate that to break dormancy of plants on short day, 6 to 8 weeks of chilling are required if treatments begin in July and 4 to 6 weeks if treatments begin in September. Long-day treatments compensated fully for lack of chilling in the July series but were not quite as effective in the September series. Thus, some progress has been made, but more observations are required before the objectives of this study are fully met.

Plantation Establishment

Soil, climate, water regime, present and past vegetative cover, site preparation, weather conditions, species to be planted and time of planting, size and condition of stock selected, planting techniques, and the spacing of the young trees--all these affect the successful survival and growth of the plantation. Planting costs, too, are determined by many of these factors.

The Station has conducted much research over the past several decades on most of these problems, especially those related to conifers. Many of the principles are now well established. Refinements continue to be obtained through periodic remeasurement of the long-term projects. New lines of investigation fill in some of the gaps.

Site preparation, especially removal of competing vegetation; reduction of damage caused by tree pests; and utilization problems are important factors affecting the establishment of plantations. Some of the more important aspects of Station research on these problems are discussed below.

Aerial Application of Herbicides Successfully Prepares Brushy Planting Sites

Much of the area in need of reforestation is covered by brush. Disks or plows successfully prepare many such areas for planting. Aerial application of herbicides is less expensive and sufficiently effective for use.

An example is a test operation in Minnesota where a 50-50 mixture of low volatile esters of 2,4-D and 2,4,5-T was applied during July at the rate of 2 pounds of acid in 4 gallons of oil-water emulsion per acre. The area was planted by hand the following May. The herbicide improved visibility and enabled the planters to place seedlings in otherwise inaccessible spots. Easier planting increased the efficiency of the crew.

The greatest benefit from herbicides was pre-release of the planted trees. After 3 growing seasons survival of red pine was 8 percent higher, and height growth 0.2 foot greater. Only 6 percent of the seedlings now need release as compared to 100 percent on untreated check areas.

White spruce was similarly benefited. Survival is 13 percent greater, height growth 0.2 foot more, release need 66 percent less. The chances are good that further release will be unnecessary where herbicides were used.

Later tests have included killing of brush before machine planting instead of hand planting. Improved visibility was a considerable factor here also.

An established red pine plantation successfully released from scrub oak by aerial spraying of herbicides.



Cheaper Mechanical Site Preparation Required

Better machinery and methods for its use are needed to remove brush and low-value species and to process economically any merchantable cover on planting sites. Needed are improved scarifiers, plows, disks, or combined ground preparation and planting machines to prepare the site; chippers, shredders, or land-clearing machines to reduce nonmerchantable material to a condition where it will not obstruct ground preparation and planting; and power harvesters, chippers, and bolters that will remove and process any salable material.

A few trials of new commercial models and some local modifications of existing equipment are made, but little formal development of this kind is being done. Development of the most efficient planting practices may require much more study of this problem.

Proper Site Selection Will Reduce Losses From White Pine Blister Rust

In the southern parts of the Lake States region the climate tends to be unfavorable for infection of white pine by blister rust. In this area rust infection of serious proportions is limited to local situations favorable to the rust. These are caused by a combination of the right elevation, topographic relief, and vegetative cover. The high-risk situations can be recognized by these characteristics. Apparently, if localized sites favorable to the rust are avoided, white pine can be grown in this area without serious losses, even though Ribes are present. A rust risk hazard key is being developed for this southern zone. Efforts are also being made to determine the northern limits of the zone in which microclimate is a limiting factor.

More knowledge of microclimatic effects is needed, particularly in the northern areas. In some situations in the North, standard Ribes eradication practices are not fully effective. Unusually favorable local climatic conditions may lead to long-distance dissemination of spores from swamp Ribes. This possibility is being checked in current work.

Plantation Management

To bring a plantation successfully to maturity requires care. In the early stages that may mean release from overtopping brush and trees. If growth and survival are good, thinning is necessary to allow the better trees more space. Crop trees must be pruned to produce special high-quality, high-value products. These jobs must be fitted together in a management pattern that will produce the greatest financial returns over the life of the stand.

Growing Space Needs Are Flexible

How much elbow room does a planted tree need? Not much at first. Then more and more as the tree grows to maturity.

The planter sets the initial pattern. Spacing is logically based on high survival and the expectation of producing usable material from the first cut. Jack pine on one poor site under study needed 7x7-foot spacing to reach pulpwood size by the time it was ready for thinning. Experience with other species and better sites leads to about the same estimate of desirable spacing. Varying survival rates complicate the picture as do the mechanical barriers to planting a full stand on many brush sites. In some cases, as many trees as it is possible to plant will still form an open stand when they have grown to pole size.

As the trees grow larger, stand improvement cuts may be made. In a reasonably full stand this is needed to allow adequate growing space for the better trees and to salvage the suppressed trees before they die. On the other hand, the degree of cutting must be carefully gauged to enable the remaining trees to make full use of the extra growing space. Measured in basal area, a pine stand of 80 to 150 square feet in well-spaced trees seems to fully utilize the area. In the plantations we have under observation, growth in cubic feet has been about equal within this range. Data from natural stands give added assurance to this estimate for pine. Data for spruce are not yet sufficient for much generalization.

A 20-year-old red pine plantation in northern Minnesota after its second thinning. This removed 9.4 cords of posts and pulpwood per acre (wood piled in background) and left 15.0 cords. The first thinning made 5 years earlier removed 1.1 cords per acre.



The tree sizes produced are affected markedly by the type of cutting and the density of the residual stand. Here's where landowner policy makes quite a difference. An illustration comes from a study of red pine pole potential in Lower Michigan. Plantation-grown trees often failed to meet specifications because of large knots induced by relatively competition free growth at uniform spacing. Basal area densities of less than 100 square feet per acre were responsible for this. To grow a greater proportion of acceptable poles, the smaller diameters grown in denser stands would have to be accepted. This may not be the best practice for production of sawtimber where larger size compensates in part for presence of limbs.

Economic Utilization of Thinnings Is Research Problem

Until the stand affords a pulpwood cut, thinning presents a problem in disposal of small material at a profit. Christmas trees, greens and decorative materials, stakes, and fence posts are possible outlets. Local markets are the determining factor in how successfully early thinning can be carried out.

Plantations use growing space efficiently if kept at proper density. Intensive practices offer means of increasing their productivity. Knowledge of how to reduce costs of handling and processing small material will find ready application in the plantings now nearing commercial size. This means new types of harvesting equipment designed for specific terrain and stand conditions and improved handling and transporting equipment. It also means cheaper methods of bark removal, chipping for pulp processing, and preservative treatment.

The Station has done little research of this kind. With the increasing acreage in plantations, however, the need for studies in the field of utilization grows more urgent.

Studies on Vegetation Control With Herbicides Continued

Experience with plantings established during the Civilian Conservation Corps program has made clear the necessity of freeing planted trees from overtopping vegetation. Otherwise survival is poor, growth negligible, and returns on the planting investment completely unsatisfactory.

This need for vegetation control has been the force behind most of the research on use of herbicides in forestry. The need has been urgent and the research of many types and on a broad front. As a result, herbicides now are being applied on thousands of plantation acres annually.

Closely controlled studies are needed to increase precision in the use of herbicides for specific purposes. A step in that direction has been

the simulation of aerial spraying on small plots. This method has been used to determine minimum doses of foliage spray needed to kill back hazel brush and mountain maple.

In hazel, tests were made with both 2,4-D and the newer herbicide, 2,4,5-TP (2,4,5-Trichlorophenoxypropionic acid), applied at 3 different concentrations and 3 volumes at each of 5 different growth stages from the middle of leaf development (early June) to just before leaf fall (late August). A preliminary analysis shows that 2,4-D gave much better top kill of this important brush at all periods than 2,4,5-TP and that mid-July applications were superior to those made either earlier or later in the growing season. Other indications are that 2 pounds per acre of 2,4-D are required to give good control of dense hazel brush; results with 1 pound per acre, a rate often recommended for brush control, were less satisfactory. Thus far, however, no consistent difference in kill has been found between plots sprayed with 1, 2, or 4 gallons of 2,4-D solution per acre.

Red Pine
Mortality
Studied

During the past few years red pine plantations that apparently were successfully established have developed needle droop, twig injuries, reduction in height growth, and excessive mortality in more or less localized areas. Examinations for evidence of disease and insects have not revealed the cause. As much of the damage is more or less localized, unfavorable soil or microclimatic conditions may be involved. Investigation of this possibility is under way.

Plantation Protection

Protecting plantations is different from protecting natural stands. They're more vulnerable to attacks by certain insects and diseases and also by fire. Often they require different methods of control because they're even-aged, relatively brush-free, and made up of only 1 or 2 species.

As planted areas in the Lake States increased and plantations began to reach the age when they are more susceptible to insect and disease attack, the need for prevention of serious losses became urgent. More and more attention has been given to plantation pests. This is especially true of research on insects because plantations probably present the most important insect problem in the region. In fire research, too, studies have recently been directed to plantation fuels.

Litter Accumulation
as a Fire Hazard

Fires in plantations tend to rise into the crown and completely destroy the trees. Furthermore, the highly inflammable fuels add greatly to the



This successfully established red pine plantation was destroyed in a few hours by a fast-moving crown fire.

difficulty of control. As a first step toward developing a more effective way of measuring fire hazard and control problems in conifer plantations, the Station made a survey of the fuels in a red pine plantation.

Results show that in younger plantings grass and herbs often account for more than half of the total weight of fuels on the forest floors, but their importance declines rapidly as the trees grow older. This fuel type is absent 25 years after planting where stocking is greater than 400 trees per acre. It disappears sooner on good sites than on poor, and in higher densities than in more open stands.

Continuous beds of needles may be formed on good sites and become a potential source of crown ignition at ages as young as 9 years; on poor sites the rate of accumulation is slower and levels off at a lower total weight. Low densities delay litter accumulation on all sites but do not reduce the ultimate level of total accumulation for the site.

Dead branches, which increase the probability of crowning in pine stands, occur at earlier ages on good sites than on poor, and they drop off sooner. High densities hasten their initial appearance and increase the number.

Exploratory Studies on Jack Pine Rusts

It is generally recognized that the jack pine - oak rust is common in the region, that it kills young trees, and that occasionally nursery stock is heavily infected. Obvious symptoms permit some culling of planting stock. A second closely related rust--the jack pine - sweetfern rust--may be more prevalent and damaging than is generally suspected. This rust does not have very obvious symptoms, but it does kill young trees and seriously deforms the stems of survivors. Plantations have been found with 30 percent of the surviving trees infected. The nature of the infections suggests that they began either in the nursery or during the first years following planting. Infected nursery stock does not usually have obvious symptoms that permit culling.

An effort is being made to determine the prevalence of these rusts, the damage caused, and how much originates in the nurseries. If it is established that nursery infection is important, nursery control measures will have to be developed.

At present work on these rusts is primarily a matter of exploratory evaluation, stimulated by the severe damage observed in some plantations.

Improved Control Methods
for European Pine Shoot Moth

For some years the European pine shoot moth has caused severe damage to red pine and, to a lesser extent, Scotch pine. Virtually all of Lower Michigan and parts of Upper Michigan and southern Wisconsin are in the infested zone. The adjacent States of Illinois, Indiana, and Ohio are also infested.

We began research on insecticidal control in Lower Michigan in the spring of 1956. To start with, the results of previous tests with DDT by various agencies were assayed. Further research revealed that damage to Christmas tree plantings can be prevented by a drenching spray in the spring. The dosage should be 3 pounds of DDT in 100 gallons of water applied at the rate of 1/10 gallon per foot of tree height. In plantations

Concentrated DDT spray being used in mist blower for control of European pine shoot moth. Using air as a carrier of DDT requires a 5-percent concentration by weight of DDT applied at the rate of 25 gallons per acre for control of shoot moth in 5-foot pine plantations.



up to 6 feet in height with 6x6-foot spacing, about 300 gallons of the spray mixture will be needed. The total cost of materials and labor will vary from \$15 to \$20 per acre depending on the height and spacing. More recently, summer treatments with a Bean mist blower with an air blast of 100 miles per hour showed that total spray volume could be reduced as much as 10 times to produce the same degree of control as drench treatments, provided the same amount of actual DDT was used.

While the prescribed treatment is practicable in Christmas tree plantings, the cost has been considered prohibitive in forest plantations. To protect recently established plantations, as well as to prevent tremendous population buildup in plantations up to 6 feet in height, the plantation manager may consider such an operation justifiable. An 84-acre red pine plantation in the Lower Michigan National Forest was treated in 1957 with good success.

So far, aerial spraying has not proved satisfactory. In part, this was due to the low dosage volume per acre. Improved equipment allowing for a larger volume of the spray solution will be tested in 1958.

Research in silvicultural control and in resistance to attack are some of the phases of this project which need more attention. Plantation density, species mixture, and height appear related to intensity of attack. Resistant individuals may be located that can serve as the parent material for development of genetically resistant strains. These lines of investigation have promise. Yet present resources allow only very limited work of this nature in 1958.

Fifteen-Year Results of Saratoga Spittlebug Research Being Summarized

Red pine plantations are particularly subject to attack by the Saratoga spittlebug (Aphrophora saratogensis (Fitch)) over a relatively large area in the north central portion of the Lake States. A constant vigil must be kept on plantations in this area until they reach a height of about 15 feet. After that, or when the crowns have closed so as to shade out the alternate hosts, the spittlebug seldom causes severe damage.

Most of the area in which red pine plantations have been established contains a lush ground cover of sweetfern, Rubus spp., Salix spp., and other ideal hosts for the spittlebug nymphs. Partial failure in many of the plantations has left enough open areas for these hosts to develop and to support large nymphal populations year after year. In the adult stage, the spittlebug moves onto the adjacent trees and sucks the plant juices from the cortex of the needle-bearing twigs. The symptoms are a shortening of the twig growth followed by yellowing of the needles, then twig and branch mortality, and finally death of the trees. The trees will run the gamut of these symptoms in 2 to 5 years depending on the intensity of the spittlebug infestation.

Fortunately, if a heavy infestation is discovered before irreparable damage has been done to the trees, this dangerous pest can be effectively controlled by treating the area with an aerial application of oil-DDT solution at the rate of 1 pound of DDT per finished gallon of insecticide per acre. Over the past 12 years, some 75,000 acres of plantations have been sprayed in northern Wisconsin and the Upper Peninsula of Michigan to prevent tree mortality and deformation. The survey and control program will probably have to be continued until the plantations have grown out of the susceptible height range.

A technical bulletin is currently in preparation to summarize all pertinent information on the Saratoga spittlebug as a plantation pest.

Other Insects Damaging to Plantations

The white pine weevil causes great damage to almost every species of native and exotic pine and spruce in the Lake States. Jack pine, white pine, and Norway spruce are the favored hosts, but in recent years weeviling of red pine has become quite common. Research to prevent widespread attacks on jack pine is needed.

Periodically one of several sawflies defoliates plantations over wide areas. A full knowledge of the life history is necessary to time correctly the known control methods. Also needed is study of the environmental factors affecting population buildup.

Additional research should be conducted on environmental factors and silvicultural control for the pine root collar weevil, the pine tortoise scale, the pine chafer, the pales weevil, and the pine leaf scale.

Most of the foliage has been stripped from these red pine trees by the red-headed pine sawfly.



Plantations and Watershed Management

At present the full effects of reforestation and type conversion by planting on watershed management are unknown in the Lake States area. The research in this field is new and results are limited and tentative. Nevertheless, available information indicates that there may be as much difference between a pine and a hardwood stand hydrologically as there is silviculturally.

Species, Spacing, and Planting Pattern Affect Character of Snow Accumulation and Melt

Species, spacing, and planting pattern determine both the amount of snow that is caught and the amount made available as usable water. They determine, too, the rate at which snow melts and contributes to spring floods.

Studies during the winter of 1956-57 traced the trend of snow accumulation and rate of melt in the major cover complexes in the northern Lake States. The amount of water in the snowpack was also measured. The difference in water content follows generally the trend of snow accumulation. A comparison of the snow pattern in an open area, a red pine plantation, and a nearby aspen stand indicates what changes may be expected when an open area is reforested or an aspen stand is converted to pine by planting.



Snow accumulated most rapidly in the open area, less rapidly under aspen, and least under red pine. When the snow began to melt, however, the order was reversed. Snow melted and ran off first from the open area, which is exposed to the direct rays of the sun, next from the aspen area, and last from the pine stand, which is well protected from the sun's rays. Thus the pine plantations can be expected to delay snowmelt longer in spring than will the aspen stand or the open field.

Snow remains longer on the protected south side (right) of this east-west strip cutting.

These results can be stated more generally. As canopy density is reduced, more snow accumulates on the ground, and spring melt takes place earlier. This has many implications in plantation establishment and management. The amount of moisture in the snow catch and the time in the spring that it is available can be influenced by species selection and thinning practice.

In addition, the planting pattern or harvesting method affects the amount of catch and rate of melt. Strips or openings made east and west accumulated more snow and retained it longer in the spring than did either strips in a north and south direction or clear-cut openings. The orientation of the east-west strips resulted in shading of the cutover land from the direct rays of the sun. These strips had the advantage of deep snow accumulation because more was intercepted and they were protected against melt during the heat of the day.

The Kind and Amount of Frost Is Related to Species

When ground freezes, different types of frost are formed and these react differently to the passage of water. Concrete frost, which is bound together by frozen ice crystals and lenses, inhibits the movement of melting snow into the ground. The presence of concrete frost is therefore an indication of spring flood-producing areas. In one study information was collected on the presence of frost types under different cover complexes. Although many factors are involved, the presence of frost was related directly to species.

Concrete frost remained longest in the open and next longest under a dense balsam fir stand where very little snow had accumulated to protect the soil. Frost was least in depth and duration under the aspen and mixed white pine - hardwood.

During the spring breakup, there was a short period of warm weather accompanied by warm spring rains. Those areas which had concrete frost were potential flood-producing areas. It is therefore interesting to note that concrete frost was found on 50 percent of the sampled points in the open area, 20 percent in the balsam fir area, and none in the other two study areas.

The conclusion is that concrete frost in open land is deeper and more widespread than in reforested areas. Of the three forest types studied, white pine - hardwood or aspen plantations would better control spring runoff from frozen ground than would a dense balsam fir stand. Studies on other forest types are needed.

Cover as Related to Runoff and Infiltration Rate

A classical use of plantations is to reduce runoff and erosion by increasing infiltration rates. The results of one experiment, conducted

in the thirties, bring this point out very clearly. The tests, made on a number of 1/200-acre lysimeters installed at La Crosse, Wis., show that the litter and organic matter which accumulate under a plantation are the major factors which help to reduce runoff and increase deep seepage.

Cover	: Duration : of : experiment ^{1/}	: Precipi- : tation :	: Runoff	: Percolation : through 4 feet : of soil		
	<u>Months</u>	<u>Inches</u>	<u>Inches</u>	<u>Percent</u>	<u>Inches</u>	<u>Percent</u>
Bare soil	20+	50.25	11.71	23.3	0	0
Bluegrass sod	20-	48.11	3.08	6.4	0	0
Scotch pine needles 2 inches deep	20-	48.11	1.30	2.7	5.19	10.8

^{1/} The experiment on bare soil lasted several weeks longer than in the other two conditions.

Some Problems in Northern Plains Planting

The research discussed in the previous pages applies mainly to planting in the three Lake States. The problems of tree establishment and care in the Northern Plains region, where the primary purpose is to protect fields and farmsteads from the wind, are of quite a different character from those in the forested regions.

We began studies on windbreak and erosion control planting in North Dakota in 1931 and continued them until World War II when the projects were put on a maintenance basis. One result of these studies was a bulletin on the broadleaved species, "Nursery Practice for Trees and Shrubs Suitable for Planting in the Prairie Plains," published in 1941 and authored by H. E. Engstrom and J. H. Stoeckeler (USDA Misc. Pub. 434).

In 1956 a Station field unit was established in Bottineau, N. Dak., and shelterbelt research was resumed. One immediate objective is to prepare a publication on nursery research on conifers in the Northern Plains as a companion piece to the one on broadleaves.

Winter Damage to Conifers Observed

To provide reasonably good wind protection in the winter, shelterbelts should contain at least one row of conifers. However, most conifers are not as well adapted to growing in the Prairie Plains as are several broadleaf species. One of the factors working against conifers is winter damage.

Following the winter of 1955-56, damage to conifers was especially noticeable. The Station made an informal survey in North Dakota to determine its extent. Attention centered on the most commonly planted conifers--ponderosa pine (Pinus ponderosa), eastern redcedar (Juniperus virginiana), and Rocky Mountain juniper (J. scopulorum). Two areas of severe damage and three of milder damage were delineated. Damage appeared only about the snowline and was generally more severe on the pine than on the junipers. It usually consisted of some loss of foliage, but in some instances pine buds were killed. Both the vigor and windbreak effectiveness of the trees were impaired. A survey of this nature could not indicate the actual cause of damage. Sudden drops of temperature after a warm moist fall, cold spells followed by warm bright days and strong winds in the winter, late spring frosts, or some combination of these conditions is most likely responsible.

The survey did show that native ponderosa pines (and junipers too) in the Badlands of western North Dakota suffered little or no winter damage. Earlier observations by the Station in the sandhills of north central North Dakota also showed that near-native sources of ponderosa pine suffered less winter damage than those from a greater distance. An answer to the problem of winter damage to ponderosa pine probably will require a combination of seed source and physiological studies.

Effect of Soil Characteristics on Growth of Green Ash Studied

The problems of shelterbelt planting in North Dakota are not, however, limited to those involving conifers. One of the backbone species in many of the established shelterbelts is green ash (Fraxinus pennsylvanica). It is grown in North Dakota where annual precipitation ranges from 14 to 22 inches and on a variety of soils. By any set of standards, it's a key species in windbreak plantings.

In 1957 the Station began a study to determine the effect of soil characteristics on the growth of this key species. As the first step, soils were sampled in 43 green ash plantings on one upland soil series where the permanent water table is beyond the reach of tree roots. The aim is to isolate the effects of soil texture and depth. Other characteristics will be studied as progress is made on the project. Growth of green ash is being correlated with that of other species as the work progresses.

Protected Boxelder Seedlings Show No Blight

Diseases and insects also must be coped with in Plains plantings. The boxelder blight is widespread and of unknown cause. Initial efforts to isolate insects from nursery stock resulted in outstanding growth of protected seedlings. A twig borer (possibly Proteoterus willingana) had been suspected, but it was not present on unprotected stock with symptoms



Experimental plot for boxelder blight, Bottineau, N. Dak. Protected boxelder at right (cage has been removed for photographing) showed normal growth and freedom from blight, whereas unprotected trees at left are both stunted and blighted. Bottom part of one of the cages appears in background.

in 1957. Shading was an uncontrolled variable and possibly an important one. Plans for 1958 include an expanded attack on the problem with soil moisture, shading, and the temperature regime included as measured variables.

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* 1956. Chemical control of brush and trees in the Lake States. L. S. Sta. Paper 41, 58 pp., illus. (Processed.)

SECOND LAKE STATES TREE IMPROVEMENT CONFERENCE.

* 1955. Second Lake States Forest Tree Improvement Conf. Proc. L. S. Misc. Rpt. 40, 108 pp., illus. (Processed.)

SHIRLEY, HARDY L.

* 1941. Restoring conifers to aspen lands in the Lake States. U. S. Dept. Agr. Tech. Bul. 763, 36 pp., illus.

SLABAUGH, PAUL E., and RUDOLF, PAUL O.

* 1957. The influence of seed source on the development of Scotch pine and Norway spruce planted in Lower Michigan (15-year results). Mich. Acad. Sci., Arts, and Letters Papers (1956) 42: 41-52, illus.

STOECKELER, J. H.

* 1947. When is plantation release most effective? Jour. Forestry 45: 265-271, illus.

and JONES, G. W.

1957. Forest nursery practice in the Lake States. U. S. Dept. Agr., Agr. Handb. 110, 124 pp., illus.

and LIMSTROM, G. A.

1942. Ecological factors influencing reforestation in northern Wisconsin. Ecol. Monog. 12: 191-212, illus.

and

* 1950. Reforestation research findings in northern Wisconsin and Upper Michigan. L. S. Sta. Paper 23, 34 pp., illus. (Processed.)

and RUDOLF, PAUL O.

* 1949. Winter injury and recovery of conifers in the Upper Midwest. L. S. Sta. Paper 18, 20 pp. (Processed.)

and

* 1956. Winter coloration and growth of jack pine in the nursery as affected by seed source. Zeitschr. f. Forstgen. u. Forstpflanzenzüchtung 5: 161-165, illus.

LIST OF PUBLICATIONS , 1957

Lake States Forest Experiment Station

General Forestry

- Arbogast, Carl, Jr., and Arend, John L. RESEARCH OF THE U. S. FOREST SERVICE IN MICHIGAN. Northeast. Logger 5(12): 22, 23, 44, illus. 1957.
(A description of forest research facilities, past results, and proposed future forest research in Michigan.)
- * Lake States Forest Experiment Station. ANNUAL REPORT, 1956. 71 pp., illus. (Processed.) 1957.
(Describes briefly the new projects and progress on established projects during 1956.)
- * Rudolf, Paul O. R. ZON, PIONEER IN FOREST RESEARCH. Sci. 125(3261): 1283-1284. 1957.
(Brief biography of Raphael Zon and listing of his major achievements in forest research.)
- Weitzman, Sidney. NEEDED--A FOREST RESEARCH PROGRAM FOR SOUTHWEST WISCONSIN. Wis. Conserv. Bul. 22(3): 28-33, illus. 1957.
(Describes the condition of the forests in southwest Wisconsin with respect to both timber production and watershed protection. Discusses the problems and conflicts which have brought about existing conditions. Outlines the research program needed to solve current problems.)

Regeneration, Stand Improvement, and Harvest Cuttings

- * Arbogast, Carl, Jr. BASIC PRINCIPLES OF FOREST MANAGEMENT IN NORTHERN HARDWOODS. Northeast. Logger 6(5): 22, 23, 58-60, illus. 1957. Also published in mimeo. form by the Station in 1956.
(Reviews in layman's terms the recommended practices for all-aged management of northern hardwoods and how to develop the ideal stand in our present forests.)
- MANAGEMENT PRACTICES IN NORTHERN HARDWOODS. The Timber Producer (Mich. and Wis.) 13(2): 8-9, illus. 1957.
(A discussion of past and present management practices in the northern hardwood type.)
- * MARKING GUIDES FOR NORTHERN HARDWOODS UNDER THE SELECTION SYSTEM. L. S. Sta. Paper 56, 20 pp., illus. 1957.
(Prescribes marking guides for properly regulated stands of all-aged northern hardwood under the selection system of management, and for irregular or unmanaged stands whose owner wishes to develop the conditions recommended for a productive forest.)

- * Conover, David F. EARLY THINNING AND PRUNING AFFECT LIMB-FREE LENGTH OF NORTHERN HARDWOODS. L. S. Tech. Note 503, 2 pp. (Processed.) 1957.
(Thinning and pruning of a northern hardwood stand--age 11 years--showed the following results in limb-free length 16 years later: Pruning was not necessary on sugar maple on unthinned plots because of rapid natural pruning, but on thinned plots pruning increased limb-free length. American elm benefitted from pruning on both thinned and unthinned plots because of its heavy branching habit and persistent dead limbs.)
- * _____ DOMINANT AND CODOMINANT SUGAR MAPLE TREES SHOULD BE FAVORED IN THINNING YOUNG STANDS. L. S. Tech. Note 509, 2 pp., illus. (Processed.) 1957.
(The success of sugar maple crop trees as measured by crown position 16 years after release depended upon original crown position and degree of thinning. At this early stand age intermediate and suppressed trees were poor risks as crop trees. Only about 15 percent of the intermediates had improved their crown position by 1954 on the heavier thinnings and results were poorer on light thinnings. Codominants benefitted most from thinnings.)
- * Dosen, R. C., Stoeckeler, J. H., and Kilp, F. G. MECHANIZED THINNING IN JACK PINE SAPLINGS. Jour. Forestry 55: 201-204, illus. 1957.
(Mechanical thinning of 2,540 acres of dense jack pine reproduction and saplings was done at 40 to 50 percent of the cost of thinning with handtools. A self-propelled 26-inch circular saw was used to cut swaths at 5- to 6-foot intervals, and portable 8- to 10-inch circular saws were used for finishing the job. Trees with a live crown ratio of 30 percent or more were favored.)
- * Godman, R. M. DISKING INCREASES THE NUMBER AND GROWTH OF YELLOW BIRCH SEEDLINGS. L. S. Tech. Note 511, 2 pp. (Processed.) 1957.
(Stocking and survival of yellow birch increased as the amount of the quadrat disked increased. Although mortality was high in all scarified areas, the number of seedlings surviving after 3 growing seasons on the quadrats with 75 percent of their area disked was 152,000 per acre. Seedling height growth was also increased by scarification.)
- * Heinselman, M. L. LIVING SPHAGNUM FOUND MOST FAVORABLE SEEDBED FOR SWAMP BLACK SPRUCE IN MINNESOTA STUDY. L. S. Tech. Note 504, 2 pp. (Processed.) 1957.
(Three seasons after clear cutting in strips, Sphagnum seedbeds accounted for 93 percent of the seedlings, yet occupied only 43 percent of the total seedbed area.)
- McCulley, Robert D. MANAGING NORTHERN HARDWOODS FOR TIMBER QUALITY PRODUCTION. Timber Prod. Bul. (Mich. and Wis.) 161: 2-3, illus. Nov.-Dec. 1956.
(Quality of present sawtimber stands is declining, there is a poor balance between the acreage being harvested and the size classes in young stands, and many poletimber stands have a large proportion of sprouts and limby trees. When sawtimber is cut, some good stems with high growth potential or good seed trees of desirable species must be left. In young stands the better stems must be favored in partial cuttings or cultural operations. Recent advances in pulping and board manufacture suggest a broadening of markets for small material that will make improvement cutting in young stands economically feasible.)

Ralston, R. A. NORTHERN HARDWOOD MANAGEMENT PROBLEMS. The Timber Producer (Mich. and Wis.) 13(3): 8-10; illus. 1957.

(A discussion of the timber quality situation and general level of forest management in the Lake States; points out management problems needing additional emphasis.)

- * Roe, Eugene I. MEASURING THE RESULTS OF AERIAL SPRAYING WITH HERBICIDES FOR FORESTRY PURPOSES. L. S. Tech. Note 492, 2 pp. (Processed.) 1957.

(Taking actual measurements of results is the only sure way to appraise aerial brush control jobs. A simple and accurate sampling method is described.)

- * _____ and Block, August E. AERIAL SPRAYING OF UPLAND BRUSH BEFORE PLANTING EFFECTIVELY REDUCES NEED FOR PLANTATION RELEASE. L. S. Tech. Note 502, 2 pp. (Processed.) 1957.

(Spraying a brushy upland site with 2,4-D and 2,4,5-T from an airplane in July 1954 not only made planting easier the next spring but also did an excellent job of brush suppression. Two growing seasons after planting, only 20 percent of the red pine and white spruce needed release from competing brush compared to 66 percent where these conifers were planted in unsprayed brush alongside. These good results were obtained for about \$6 per acre; this is only about one-third the cost of disking, the usual method of preparing brushy upland sites for planting.)

- * _____ GROWTH OF ESTABLISHED BALSAM FIR REPRODUCTION GREATLY STIMULATED BY CUTTING. L. S. Tech. Note 512, 2 pp. (Processed.) 1957.

(Balsam fir stands typically have large numbers of small seedlings which live for a few years, only to be replaced by younger ones. All that is needed to favor the growth and development of such seedlings into reproduction of more promising size is opening up the crown canopy. At the initiation of a cutting study on this species in northern Minnesota, only 3 to 7 percent of all balsam seedlings were 1 foot or taller; 5 years later the proportion was only 5 percent in the uncut check, 8 percent in the light cutting, but 10 to 27 percent in the 3 heavier cuttings.)

- * Rudolf, Paul O. 1956 FOREST TREE SEED CROP SUBNORMAL IN THE LAKE STATES. L. S. Tech. Note 501, 2 pp. (Processed.) 1957.

(Seed crops for the principal forest tree species are listed in percentage of full crops for northern Minnesota, northeastern Wisconsin, central Upper Michigan, Lower Michigan, and north central North Dakota. Generally the best production was in central Upper Michigan.)

- * Scholz, Harold F., and DeVriend, A. J. NATURAL REGENERATION ON A 2-ACRE MIXED-OAK CLEAR CUTTING FIVE YEARS AFTER LOGGING. L. S. Sta. Paper 48, 11 pp., illus. (Processed.) 1957.

(Observations made during the first 5-year period following the clear cutting of a 2-acre block of mature oak in Fond du Lac Co., Wis., indicate that seedling regeneration of northern red oak and other valuable species is adequate--7,080 stems per acre--for restocking. However, the final evaluation of clear cutting by small blocks as an approved silvicultural system for managing oak cannot be made until we learn how many of these seedlings come through the competing cover of woody shrubs.)

- * Skilling, Darroll D. TWELVE-YEAR RESULTS OF A MECHANICAL THINNING IN OVER-DENSE JACK PINE. L. S. Tech. Note 489, 2 pp. (Processed.) 1957.
(Gives results of using an Athens disk-plow to thin jack pine saplings by three different methods. Leaving 3-foot strips between 6-foot disked areas provided best release.)
- * _____ IS THE EPICORMIC BRANCHING ASSOCIATED WITH HARDWOOD PRUNING WOUNDS INFLUENCED BY TREE CROWN CLASS? L. S. Tech. Note 510, 2 pp. (Processed.) 1957.
(A study of artificially pruned northern hardwoods revealed the importance of tree crown class on the development of epicormic branches following pruning; 87 percent of the pruned suppressed trees developed epicormic branches as compared with only 1 percent of the pruned dominant trees.)
- * Slabaugh, Paul E. DO PRUNED RED PINE TREES REMAIN DOMINANT? L. S. Tech. Note 476, 2 pp., illus. (Processed.) 1957.
(Pruning crop trees in excess of 50 percent of the live crown length resulted in loss of dominance in a 5-year period following treatment. Percent of crop trees losing dominance increased with severity of pruning.)
- * _____ THE EFFECTS OF LIVE CROWN REMOVAL ON THE GROWTH OF RED PINE. Jour. Forestry 55: 904-906, illus. 1957.
(Crop trees were pruned to 30, 50, 70, and 90 percent of the live crown length, and their growth over a 5-year period compared to that of unpruned trees. Height growth rate was affected less by pruning than was diameter. Loss of dominance occurred when the trees were pruned to 70 and 90 percent of their total live crown lengths.)
- * Stoeckeler, J. H. ANNUAL LUPINES AND OTHER COVER CROPS FOR THE FOREST NURSERIES OF THE LAKE STATES. Soil Sci. Soc. Amer. Proc. 21: 543-546. 1957.
(Blue, white, and sweet yellow lupines were tested as a green manure crop in forest nurseries in northeastern Wisconsin and Michigan. Also tested were vetch, soybeans, seradella, and rye for comparisons. Sweet yellow lupine produced on an average 4,392 pounds of overdry bulk per acre with an average nitrogen content of 89 pounds per acre. Blue lupine and hairy vetch on occasion gave good results, but were not as consistent as yellow lupine.)
- _____ and Jones, G. W. FOREST NURSERY PRACTICE IN THE LAKE STATES. Forest Serv., U. S. Dept. Agr., Agr. Handb. 110, 124 pp., illus. 1957.
(This book covers all aspects of nursery practice in the Lake States. Major items included are collection and handling of seed; how to select and develop a nursery site; equipment; soil management; age classes of stock needed for reforestation; seedbed preparation and sowing; soil moisture and irrigation; seedbed care during germination and seedling stage; transplanting; hardening off; special preparation methods; nursery protection, especially against insects, disease, and rodents; inventory methods; and the lifting, grading, packing, storing, and shipping of trees.)

- * Strothmann, Rudolph O., and Heinselman, Miron L. FIVE-YEAR RESULTS IN AN ASPEN SUCKER DENSITY STUDY. L. S. Tech. Note 490, 2 pp. (Processed.) 1957.

(For the first 5 years after thinning of a 1-year-old quaking aspen stand it was found that stand density had little effect on height growth, but that survival decreased with increasing density.)

- * Thornton, Philip L. PROBLEMS OF MANAGING UPPER MICHIGAN'S CONIFEROUS SWAMPS. Jour. Forestry 55: 192-197, illus. 1957.

(A discussion of the potential of mixed coniferous swamps in Michigan and some of the management problems.)

- * _____ EFFECTS OF CUTTING METHODS ON ADVANCE REPRODUCTION IN TWO MATURE MIXED CONIFEROUS SWAMPS IN UPPER MICHIGAN. Jour. Forestry 55: 448-451, illus. 1957.

(Some measurable characteristics of reproduction in two mixed coniferous swamps, which were cut by five different methods.)

- * Zasada, Zigmond A., and Buckman, Robert E. GROWTH AND YIELD OF A YOUNG RED PINE PLANTATION IN NORTHERN MINNESOTA. L. S. Tech. Note 491, 2 pp. (Processed.) 1957.

(A 22-year-old red pine plantation on the Pike Bay Experimental Forest has already produced nearly 26 cords of pulpwood to a 3-inch top. This unusually high growth rate is attributed largely to intensive ground preparation and release during its first few years.)

Forest Genetics

- Nienstaedt, Hans. REVIEW OF "PLANT PROPAGATION" BY JOHN P. MAHLSTEDT AND ERNEST S. HABER. Jour. Forestry 55: 383-384. 1957.

- Olson, Jerry S., and Nienstaedt, Hans. PHOTOPERIOD AND CHILLING CONTROL GROWTH OF HEMLOCK. Sci. 125(3246): 492-494, illus. 1957.

(The length of the period of growth in hemlock is a function of photoperiod. Maximum period of growth and therefore elongation is obtained at a 20-hour photoperiod. Other phases of the growth controlled or modified by photoperiod are dormancy and seed germination.)

- Rudolf, Paul O. FOREST TREE SEED COLLECTION ZONES FOR THE LAKE STATES. Forestry Div., Mich. Dept. Conserv., 14 pp., illus. (Processed.) 1957.

(Proposes a series of seed collection zones for the Lake States based on (1) a summation of normal average daily temperatures per year above 50° F. "growth degrees", and (2) mean January temperatures.)

- * Slabaugh, Paul E., and Rudolf, Paul O. THE INFLUENCE OF SEED SOURCE ON THE DEVELOPMENT OF SCOTCH PINE AND NORWAY SPRUCE PLANTED IN LOWER MICHIGAN (15-YEAR RESULTS). Mich. Acad. Sci., Arts, & Letters Papers (1956) 42: 41-52, illus. 1957.

(Compares the performance of Scotch pine of 10 European origins and Norway spruce of 12 European origins with that of red pine and white pine of Michigan origin. The native species have been less subject to damaging agents and are growing faster.)

Soils and Water

- * Dils, Robert E. WATERSHED MANAGEMENT RESEARCH NEEDS IN THE FORESTS OF THE LAKE STATES. Mich. State Univ. Agr. Expt. Sta. Spec. Bul. 416, 35 pp., illus. 1957.

(This bulletin provides a survey of watershed management research needs in the northern forest area and the Driftless Area of the Lake States. It describes the water resources and requirements and the problems in watershed management. Background information includes climate, topography and geology, soils, and land use.)

- * Thames, John L., and Swensen, Edmond I. PROPERTIES OF 160 SOILS OF FOUR NORTH CENTRAL STATES. L. S. Sta. Paper 38, 15 pp., illus. 1957.

(Characterizes the individual sample sites and summarizes the information on properties of soils at 160 sites in Iowa, Minnesota, Wisconsin, and Illinois.)

- Weitzman, Sidney. PROBLEMS OF WATERSHED MANAGEMENT. The Conserv. Volunteer 20(115): 8-13, illus. 1957.

(Reports the establishment of a watershed management research program in Minnesota. Outlines some of the present water problems in the area and discusses factors which will create an increased demand in the future.)

- _____. THERE'S WATER IN THE FORESTS. The Conserv. Volunteer 20(116): 18-22, illus. 1957.

(Gives some facts about the interrelations of forests and water. Discusses the management of the forests for multiple uses, including watershed protection. Outlines the research program planned for Minnesota, which is designed to help solve existing problems.)

Fire

- LaMois, L. M. FIRE HISTORY AND THE PRESENT SITUATION IN NORTHERN WOODS. The Timber Producer (Mich. and Wis.) 13(4): 16-18, illus. 1957.

(Character and extent of past losses due to fire were caused mainly by timber harvest methods, with subsequent large and uncontrollable fires. Future losses should be reduced through less drastic cutting methods and better utilization.)

Forest Insects

- Bean, James L. SPRUCE BUDWORM IS A KILLER. The Conserv. Volunteer 20(116): 34-38, illus. 1957.

(A nontechnical presentation of the present spruce budworm outbreak in the United States, with special reference to the problem in Minnesota.)

- _____. SPRUCE BUDWORM RESEARCH AND MANAGEMENT RECOMMENDATIONS. Ent. Soc. Amer., 12th Ann. Meeting No. Central Branch Proc. 1957: 14-15. (Processed.) 1957.

(Outlines a research program initiated by the Station to investigate the biology and ecology of the spruce budworm in the Lake States and to develop management practices to reduce losses by this insect. Tentative conclusions based on 2 years' research are presented.)

- * _____ and Batzer, H. O. MEAN HEAD WIDTH FOR SPRUCE BUDWORM LARVAL INSTARS IN MINNESOTA AND ASSOCIATED DATA. Jour. Econ. Ent. 50: 499. 1957.
(Presents data on larval head capsule widths that are useful for separating the different larval stages. Such information is essential in properly timing aerial spraying operations.)
- * _____ and Graeber, Hart. SPRUCE BUDWORM INCREASING IN MINNESOTA. L. S. Tech. Note 479, 2 pp., illus. (Processed.) 1957.
(A brief report on the spruce budworm situation in Minnesota as determined from aerial and ground surveys.)
- Beckwith, L. C. JACK-PINE BUDWORM SITUATION IN THE LAKE STATES. Ent. Soc. Amer., 12th Ann. Meeting No. Central Branch Proc. 1957: 12. (Processed.) 1957.
(Heavy feeding by this insect occurred in the Lake States in 1955 and 1956. Surveys in 1956 indicated the probable need for aerial spraying with DDT on more than 200,000 acres of jack pine type in Wisconsin.)
- * _____ TAMARACK MORTALITY DUE TO LARCH SAWFLY DEFOLIATION INCREASES IN MINNESOTA. L. S. Tech. Note 487, 2 pp. (Processed.) 1957.
(Tamarack mortality due to larch sawfly defoliation has become apparent in the better tamarack sites in north central Minnesota. Much of this mortality occurred in the 2-inch diameter class.)
- * _____ WEATHER STATION RECORDS NOT AN ACCURATE GUIDE TO TEMPERATURES LETHAL TO THE SHOOT MOTH. L. S. Tech. Note 508, 2 pp., illus. (Processed.) 1957.
(Temperatures in plantations near Lake Michigan were consistently higher than temperatures registered at official weather station; they were never near the lethal range during the course of the study.)
- Drooz, A. T. THE IMPORTANCE OF MESOLEIUS TENTHREDINUS MOR., A PARASITE OF THE LARCH SAWFLY, IN NEW YORK STATE. Jour. Econ. Ent. 50: 212. 1957.
(Parasitism amounted to 56 percent of the 95 live larvae in the collection. Immunity reaction is not present in the New York sawfly according to these observations.)
- * _____ SPRAY CHAMBER INSECTICIDE TESTS ON THE LARCH SAWFLY. Canad. Ent. 89: 183-187, illus. 1957.
(BHC, malathion, and DDT were tested in a spray chamber to determine the effectiveness of each against the larvae of the larch sawfly. At the concentrations and dosages, DDT failed; BHC and malathion gave satisfactory results, the former being more potent against 4th- and early 5th-instar larvae.)
- * Ewan, H. G. THE JACK-PINE SAWFLY. U. S. Forest Service Forest Pest Leaflet 17, 4 pp., illus. 1957.
(A summary of information on the description, life cycle, distribution, damage, host range, and control of the jack-pine sawfly.)
- MacAloney, H. J. FOREST INSECTS IN THE NORTHERN HARDWOOD TYPE. The Timber Producer (Mich. and Wis.) 13(6): 6-7. 1957.
(A brief statement covering the important insects which can cause tree mortality, growth loss, and lumber degrade in the important tree species in the northern hardwood type in the Lake States.)

- * THE RED-HEADED PINE SAWFLY. U. S. Forest Serv. Forest Pest Leaflet 14, 4 pp., illus. 1957. Also Timber Prod. Assoc. Monthly Bul. 12(9): 14. 1957.

(A brief account of the life history, habits, hosts, and range of the insect, and suggestions for its control and for preventing damage.)

- THE SPRUCE BUDWORM--A DEVASTATING FOREST PEST. Ent. Soc. Amer., 12th Ann. Meeting No. Central Branch Proc. 1957: 13. (Processed.) 1957.

(Historical review of spruce budworm epidemics in Canada and the United States since 1770, and a brief discussion of the outbreaks in the Lake States and adjacent Canada since 1910.)

Forest Diseases

- Anderson, R. L. FOREST DISEASES CAUSE SERIOUS LOSSES IN MERCHANTABLE NORTHERN HARDWOOD. The Timber Producer (Mich. and Wis.) 13(6&7): 10-11. 1957.

(Growth loss in northern hardwoods caused by disease is estimated to be 65 percent as great as the net growth. Almost all of this estimated loss is caused by heart rots. Intensified management and utilization will materially reduce this loss.)

- * Anderson, Gerald W., and Anderson, Ralph L. THE LOCAL SPREAD OF OAK WILT, 1955 TO 1956. L. S. Tech. Note 480, 2 pp., illus. (Processed.) 1957.

(Average radial spread per year of all established infection centers was 3.5 feet. The average for active centers was 6.5 feet.)

- * and OAK WILT--LONG-DISTANCE SPREAD, 1955 AND 1956. L. S. Tech. Note 481, 2 pp., illus. (Processed.) 1957.

(New infection centers were established at the rate of 1.7 centers in 1955 and 1.8 centers in 1956 per 100 acres of oak type.)

- * Beckwith, L. C., and Anderson, R. L. BOXELDER BLIGHT A PROBLEM IN THE NORTHERN PLAINS STATES. L. S. Tech. Note 482, 2 pp. (Processed.) 1957.

(A blight of unknown cause is widespread on boxelder in North Dakota. Typical symptoms are small chlorotic leaves on the new shoots.)

- * Hesterberg, Gene A. DETERIORATION OF SUGAR MAPLE FOLLOWING LOGGING DAMAGE. L. S. Sta. Paper 51, 58 pp., illus. (Processed.) 1957.

(Maples with 10- and 20-year-old logging scars were dissected to determine the amount of cull and degrade caused by the injury. The amount of defect was found to be related to the size of the wound and the length of time since wounding.)

- * LOGGING DAMAGE RISK CLASSIFICATION FOR SUGAR MAPLE. L. S. Tech. Note 488, 2 pp. (Processed.) 1957.

(Indicates the decay risk for 10- and 20-year-old logging scars and branch stubs of various sizes.)

- Van Arsdel, E. P., Parmeter, J. R., and Riker, A. J. ELEVATION EFFECTS ON TEMPERATURE AND RAINFALL CORRELATED WITH BLISTER RUST DISTRIBUTION IN SOUTHWESTERN WISCONSIN. Phytopath. 47: 536. 1957. (Abstract of paper presented at annual meeting.)

(In southwestern Wisconsin, blister rust prevalence was found to be associated with microclimate as follows: Below 900 feet, practically absent; 900-1100 feet, largely limited to microclimatically cool sites; above 1100 feet, on most sites; and above 1200 feet, occasionally severe.)

Forest Wildlife

Hansen, H. L., and Krefting, L. W. MODERN SPRAYS INCREASE BROWSE. The Conserv. Volunteer 20(117): 21-25, illus. 1957.

(An account of the results of experiments using herbicides to top kill mountain maple for inducing regrowth for deer browse.)

* Stoeckeler, J. H., Strothmann, R. O., and Krefting, L. W. EFFECT OF DEER BROWSING ON REPRODUCTION IN THE NORTHERN HARDWOOD-HEMLOCK TYPE IN NORTH-EASTERN WISCONSIN. Jour. Wildlife Mangt. 21(1): 75-80, illus. 1957.

(A period of 6 to 8 years of low deer population is needed in second-growth hardwood-hemlock stands to permit successful regeneration and the adequate growth of understory seedlings.)

Silvics

(The seven reports listed below briefly summarize knowledge concerning the distribution, habitat conditions, life history, special features, and genetic factors of the designated tree species. The Station is preparing similar reports on eight additional species.)

* Godman, R. M. SILVICAL CHARACTERISTICS OF SUGAR MAPLE (ACER SACCHARUM MARSH.). L. S. Sta. Paper 50, 24 pp., illus. (Processed.) 1957.

* Guilkey, Paul C. SILVICAL CHARACTERISTICS OF AMERICAN ELM (ULMUS AMERICANA L.). L. S. Sta. Paper 54, 19 pp., illus. (Processed.) 1957.

* Heinselman, M. L. SILVICAL CHARACTERISTICS OF BLACK SPRUCE (PICEA MARIANA MILL.). L. S. Sta. Paper 45, 30 pp., illus. (Processed.) 1957.

* Roe, Eugene I. SILVICAL CHARACTERISTICS OF TAMARACK (LARIX LARICINA (DuROI) K. KOCH). L. S. Sta. Paper 52, 22 pp., illus. (Processed.) 1957.

* Rudolf, Paul O. SILVICAL CHARACTERISTICS OF RED PINE (PINUS RESINOSA AIT.). L. S. Sta. Paper 44, 32 pp., illus. (Processed.) 1957.

* Scholz, Harold F. SILVICAL CHARACTERISTICS OF ROCK ELM (ULMUS THOMASII SARG.). L. S. Sta. Paper 47, 16 pp., illus. (Processed.) 1957.

* Strothmann, R. O., and Zasada, Z. A. SILVICAL CHARACTERISTICS OF QUAKING ASPEN (POPULUS TREMULOIDES MICHX.). L. S. Sta. Paper 49, 26 pp., illus. (Processed.) 1957.

Estimation of Timber Volume, Growth, and Yield

Gevorkiantz, S. R.

- * SITE INDEX CURVES FOR WHITE-CEDAR IN THE LAKE STATES. L. S. Tech. Note 472.
- * SITE INDEX CURVES FOR BLACK SPRUCE IN THE LAKE STATES. L. S. Tech. Note 473.
- * SITE INDEX CURVES FOR WHITE SPRUCE IN THE LAKE STATES. L. S. Tech. Note 474.
- * SITE INDEX CURVES FOR WHITE PINE IN THE LAKE STATES. L. S. Tech. Note 483.
- * SITE INDEX CURVES FOR RED PINE IN THE LAKE STATES. L. S. Tech. Note 484.
- * SITE INDEX CURVES FOR RED OAK IN THE LAKE STATES. L. S. Tech. Note 485.
- * SITE INDEX CURVES FOR TAMARACK IN THE LAKE STATES. L. S. Tech. Note 498.

(Each of the above Technical Notes--processed--is 2 pages, illus. Each presents site index curves for a species and explains their uses and limitations; published in 1957.)

- * Horn, Arthur G. TREE DIAMETER AT BREAST HEIGHT IN RELATION TO STUMP DIAMETER BY SPECIES GROUP. L. S. Tech. Note 507, 2 pp. (Processed.) 1957.

(A convenient table for converting tree stumps to d.b.h. by species groups; also a simple rule-of-thumb for making quick conversions.)

- * Stoeckeler, J. H., and Olsen, L. P. A REGRESSION EQUATION RELATING DIAMETER GROWTH RATE OF JACK PINE TO LIVE CROWN PERCENT. Jour. Forestry 55: 467, illus. 1957.

(In dense 26-year-old jack pine in central Wisconsin, trees with only 10 percent of their total height in live crown grew 0.07 inch in diameter in 5 years, at 20 percent 0.30 inch, at 30 percent 0.52 inch, and at 40 percent 0.68 inch. These observations have been useful as a guide in thinning young stands.)

Forest Economics

- Horn, Arthur G. THE MODERN FOREST INDUSTRY. The Conserv. Volunteer 20(117): 45-51, illus. 1957. Also in Timber Prod. Assoc. Monthly Bul. 12(10): 8-11. 1957.

(Discusses importance of second-growth timber in Minnesota's economy. Shows number of primary wood-using plants dependent on local timber and the quantity of rough forest products harvested annually in different sections of the State. Suggests increased use of some timber species through expansion of some segments of Minnesota's timber industry.)

- * Yoho, James G., James, Lee M., and Quinney, Dean N. PRIVATE FOREST LAND-OWNERSHIP AND MANAGEMENT IN THE NORTHERN HALF OF MICHIGAN'S LOWER PENINSULA. Mich. State Univ. Agr. Expt. Sta. Tech. Bul. 261, 56 pp., illus. 1957.

(Private landowners own 65 percent of the commercial forest land in the northern half of Lower Michigan. Of these, 30 percent are farmers or part-time farmers, while the rest are a diverse occupation group, most of whom do not reside full time on the forest property. Characteristics of ownership such as distance of residence from forest land, length of tenure, and age of owners, were found to be related to timber management. A leading obstacle to better timber management seems to be failure or inability of owners to provide supervision over the property because of physical limitations or the demands of more profitable activities.)

Timber Resource and Production Statistics

- * Chase, Clarence D., and Horn, Arthur G. TIMBER RESOURCES, GOGEBIC AND ONTONAGON COUNTIES, MICHIGAN. Mich. Dept. Conserv., 46 pp., illus. 1957.

(Presents forest area, timber volumes, growth, allowable cut, and timber cut for each of the two counties.)

- Cunningham, R. N. NORTHERN HARDWOODS--A MAJOR TIMBER RESOURCE IN THE LAKE STATES AREA. The Timber Producer (Mich. and Wis.) 13(1): 1-2, illus. 1957.

(Discusses in layman's terms the extent of the northern hardwood type in the Lake States, the sawtimber volume in its principal species, and the changes in distribution of stand-size classes between 1936 and 1953.)

- * Guilkey, Paul C. THE HARDWOOD RESOURCES IN LOWER MICHIGAN, AND CURRENT AND POTENTIAL USES. Forest Prod. Jour. 7(11): 23a-25a, illus. 1957.

(Survey of hardwood area, volume, quality, growth, and cut shows need for fuller utilization of low-quality hardwood timber to halt the decline of hardwood sawtimber quality. Forecasts increased demand for traditional products using high-grade timber and rapid expansion into new products using fiber, particles, and short cuttings from low-grade timber.)

Horn, A. G.

- * LAKE STATES PULPWOOD PRODUCTION REACHES NEW HIGH. L. S. Tech. Note 495.
- * LAKE STATES VENEER LOG PRODUCTION AND IMPORTS SHOW SLIGHT INCREASE IN 1956. L. S. Tech. Note 496, illus.
- * USE OF VENEER LOGS BY CONTAINER INDUSTRY ON DECLINE IN LAKE STATES. L. S. Tech. Note 497, illus.
- * PRODUCTION OF CHEMICAL AND CHARCOAL WOOD INCREASES IN THE LAKE STATES, 1956. L. S. Tech. Note 505, illus.
- * ANNUAL CUT OF EXCELSIOR BOLTS STARTS TO CLIMB, LAKE STATES. L. S. Tech. Note 506, illus.

(Each of these 2-page Notes--processed, 1957--shows production by species in Minnesota, Wisconsin, and Michigan, and imports from other States and Canada. Pulpwood Note shows movement between States in region. Other four Notes show trend in production for each of the States from 1946 through 1956.)

- * A RECORD OF THE TIMBER CUT FROM FORESTS OF THE LAKE STATES, 1954. L. S. Sta. Paper 53, 47 pp., illus. (Processed.) 1957.

(Shows trends in timber cutting and production of forest products during the past few years by States, products, and species groups. For 1954 shows timber removed through cutting by product, species, and State; also forest products harvested and imported by State for individual products.)

- * Keller, Richard C. FUELWOOD AND FENCE POST PRODUCTION IN MINNESOTA BY COUNTIES, 1953-54 LOGGING SEASON. L. S. Tech. Note 486, 2 pp. (Processed.) 1957.

(Shows the production of fuelwood and fence posts by species and counties.)

Morgan, J. T., and Dickerman, M. B. COMMENTS ON THE TIMBER RESOURCE OF NORTHERN LOWER MICHIGAN. U. S. Forest Serv., Lake States Forest Expt. Sta., 6 pp. (Mimeo.) 1957. (Presented at annual meeting of Wis.-Mich. Section Soc. Amer. Foresters, Sept. 19, 1957.)

(Summarizes changes in the timber resource since the thirties: more forest land, an improvement in stocking in all size classes of aspen type, an increase in softwood types largely due to planting of red pine, and an increase in the oak area; a rise in sawlog material, and cordwood volume nearly double; and a threefold increase in pulpwood consumption. Both growth and allowable cut exceed actual cut. Development of optimum conditions for timber growth is hampered by lack of knowledge and interest by many small private owners.)

Office of Iron Range Resources and Rehabilitation and
Lake States Forest Experiment Station

- * THE FOREST RESOURCE OF SOUTHWESTERN MINNESOTA. Office Iron Range Res. and Rehab., 47 pp., illus. 1957.
- * THE FOREST RESOURCE OF SOUTHEASTERN MINNESOTA. Office Iron Range Res. and Rehab., 60 pp., illus. 1957.

(Each report presents forest areas, timber volumes, growth, allowable cut, and timber cut for the Block and, insofar as feasible, for each county.)

- * Rapp, Dennis A., Chase, Clarence D., and Horn, Arthur G. TIMBER RESOURCES, GLADWIN BLOCK, LOWER PENINSULA, MICHIGAN. Mich. Dept. Conserv., 49 pp., illus. 1957.

(Presents forest area, timber volume, growth, allowable cut, and timber cut for the Block and, insofar as feasible, for each county.)

Ritter, L. B., and Cunningham, R. N. AN INVENTORY OF OUR FORESTS. The Conserv. Volunteer 20(118): 1-4, illus. 1957.

(Summarizes area, volume, growth, mortality, cut, and ownership of forest lands and timber in the Lake States; discusses briefly the major trends since the thirties.)

Stoeckeler, J. H. REVIEW OF "WISCONSIN'S RENEWABLE RESOURCES" BY JAMES A. LARSEN. Jour. Forestry 55: 472. 1957.

- * Vasilevsky, Alexander M. OWNERSHIP OF COMMERCIAL FOREST LAND IN MINNESOTA COUNTIES. L. S. Tech. Note 475, 2 pp., illus. (Processed.) 1957.

(Shows distribution of commercial forest land by county and ownership group.)

Wisconsin Conservation Department and Lake States Forest Experiment Station.

- * FOREST RESOURCES OF SHAWANO COUNTY. Wis. Conserv. Dept. Forest Inventory Pub. 26, 37 pp., illus.
- * FOREST RESOURCES OF LANGLADE COUNTY. Wis. Conserv. Dept. Forest Inventory Pub. 27, 37 pp., illus.
- * FOREST RESOURCES OF FLORENCE COUNTY. Wis. Conserv. Dept. Forest Inventory Pub. 28, 31 pp., illus.
- * FOREST RESOURCES OF MARINETTE COUNTY. Wis. Conserv. Dept. Forest Inventory Pub. 29, 37 pp., illus.
- * FOREST RESOURCES OF OCONTO COUNTY. Wis. Conserv. Dept. Forest Inventory Pub. 30, 31 pp., illus.

(Each report--processed, 1957--presents forest area by type, size, density, and ownership; volume, growth, timber cut, and allowable cut by type and species.)

Timber Utilization and Marketing

- * Dickerman, M. B. FOREST RESEARCH AIDS BETTER TIMBER UTILIZATION. Amer. Forests 63(11): 20, 21, 56, 57, illus. 1957.

(The Station and cooperating agencies are giving increasing attention on how to improve growth and assure fullest use of the timber resource. Some of the research in this field includes studies on: Reforestation to ensure successful plantations of the better species; genetics to improve quality and pest resistance of trees; insect, disease, and fire control methods to protect existing stands; thinning to ensure larger and

better quality trees; cutting methods to favor natural reproduction of the valuable species; markets for low-quality material that should be removed; logging methods that will not damage residual trees.)

- * Lane, Paul H. DESIGN OF A CINDER-CONCRETE BLOCK CHARCOAL KILN. L. S. Tech. Note 494, 2 pp., illus. (Processed.) 1957.

(Describes and presents schematic drawing of an improved 3-cord charcoal kiln costing about \$350 for materials.)

- * _____ and Boldt, Charles E. THE CHARCOAL RESEARCH PROGRAM OF THE LAKE STATES FOREST EXPERIMENT STATION. The Timber Producer (Mich. and Wis.) 13(5): 16-17, illus. 1957.

(Discusses the objectives of the Station's research program on the manufacture of charcoal in kilns and gives some of the results.)

- * Warner, John R., and Lord, William B. THE MARKET FOR DOMESTIC CHARCOAL IN WISCONSIN. L. S. Sta. Paper 46, 15 pp., illus. (Processed.) 1957.

(Discusses the size of the market for bagged charcoal in Wisconsin in 1955 and describes marketing activities.)

- * _____ HOW LARGE IS THE CHARCOAL MARKET? L. S. Tech. Note 477, 2 pp., illus. (Processed.) 1957.

(A brief evaluation of the market for domestic charcoal in Wausau, Wis.)

- * _____ DISTRIBUTION CHANNELS USED BY WOOD PALLET MANUFACTURERS SELLING IN THE MINNEAPOLIS-ST. PAUL AREA. L. S. Tech. Note 478, 1 p., illus. (Processed.) 1957.

(Shows lines of sales efforts for 19 pallet manufacturers supplying Twin Cities industries.)

- * THE TWIN CITIES TRANSPORTATION EQUIPMENT INDUSTRY AS A USER OF WOOD. L. S. Tech. Note 493. 1957.

- * THE TWIN CITIES PRIMARY METAL INDUSTRIES AS USERS OF WOOD. L. S. Tech. Note 499. 1957.

- * THE TWIN CITIES FABRICATED METAL PRODUCTS INDUSTRIES AS USERS OF WOOD. L. S. Tech. Note 500. 1957.

- * THE TWIN CITIES ELECTRICAL MACHINERY INDUSTRIES AS USERS OF WOOD. L. S. Tech. Note 513. 1957.

- * THE TWIN CITIES NONELECTRICAL MACHINERY INDUSTRIES AS USERS OF WOOD. L. S. Tech. Note 514. 1957.

(Each of these 2-page, illustrated, processed Technical Notes discusses briefly the species, volume, form, source, and use of lumber purchased in 1956 by firms in the designated industries.)